

1           ANATOMICAL DISTAL RADIUS FRACTURE FIXATION PLATE  
2                           AND METHODS OF USING THE SAME  
3

4           This application is a continuation-in-part of U.S. Serial No. 10/401,089, filed  
5   March 27, 2003, which is hereby incorporated by reference herein in its entirety.  
6

7                           BACKGROUND OF THE INVENTION  
8

9   1. Field of the Invention

10           This invention relates broadly to surgical implants. More particularly, this  
11   invention relates to a bone fracture fixation system for distal radius fractures.  
12

13   2. State of the Art

14           Fracture to the metaphyseal portion of a long bone can be difficult to treat.  
15   Improper treatment can result in deformity and long-term discomfort.  
16

17           By way of example, a Colles' fracture is a fracture resulting from compressive  
18   forces being placed on the distal radius, and which causes backward or dorsal  
19   displacement of the distal fragment and radial deviation of the hand at the wrist. Often, a  
20   Colles' fracture will result in multiple bone fragments which are movable and out of  
21   alignment relative to each other. If not properly treated, such fractures may result in  
22   permanent wrist deformity and limited articulation of the wrist. It is therefore important

1 to align the fracture and fixate the bones relative to each other so that proper healing may  
2 occur.

3

4 Alignment and fixation of a metaphyseal fracture (occurring at the extremity of a  
5 shaft of a long bone) are typically performed by one of several methods: casting, external  
6 fixation, interosseous wiring, and plating. Casting is non-invasive, but may not be able to  
7 maintain alignment of the fracture where many bone fragments exist. Therefore, as an  
8 alternative, external fixators may be used. External fixators utilize a method known as  
9 ligamentotaxis, which provides distraction forces across the joint and permits the fracture  
10 to be aligned based upon the tension placed on the surrounding ligaments. However,  
11 while external fixators can maintain the position of the wrist bones, it may nevertheless  
12 be difficult in certain fractures to first provide the bones in proper alignment. In addition,  
13 external fixators are often not suitable for fractures resulting in multiple bone fragments.  
14 Interosseous wiring is an invasive procedure whereby screws are positioned into the  
15 various fragments and the screws are then wired together as bracing. This is a difficult  
16 and time-consuming procedure. Moreover, unless the bracing is quite complex, the  
17 fracture may not be properly stabilized. Plating utilizes a stabilizing metal plate typically  
18 against the dorsal side of the bones, and a set of parallel pins extending from the plate  
19 into holes drilled in the bone fragments to provide stabilized fixation of the fragments.  
20 However, many currently available plate systems fail to provide desirable alignment and  
21 stabilization.

22

In particular, with a distal radius fracture the complex shape of the distal radius, including the bulky volar rim of the lunate fossa, relatively flat volar rim of the scaphoid fossa, and volar marginal fragment from the lunate fossa should be accommodated. A fixation plate should provide desirable alignment and stabilization of both the subchondral bone and the articular surfaces of the distal radius.

## SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide an improved fixation system for distal radius fractures.

It is another object of the invention to provide a distal radius volar fixation system that desirably aligns and stabilizes multiple bone fragments in a fracture to permit proper healing.

It is also an object of the invention to provide a distal radius volar plate system which provides support for articular and subchondral surfaces.

It is an additional object of the invention to provide a distal radius volar plate system which accommodates the anatomical structure of the metaphysis of the distal radius.

1           It is a further object of the invention to provide a distal radius volar plate system  
2   which provides support without interfering with ligaments and soft tissues near the edge  
3   of the articular surface.

4  
5           In accord with these and other objects, which will be discussed in detail below, a  
6   distal radius volar fixation system is provided. The system generally includes a plate  
7   intended to be positioned against the volar side of the radius, a plurality of bone screws  
8   for securing the plate along a non-fractured portion of the radius bone, a plurality of bone  
9   pegs sized to extend from the plate and into bone fragments at the metaphysis of a radius  
10   bone, and one or more K-wires to facilitate alignment and fixation of the plate over the  
11   bone and guide the process of application.

12  
13          The plate is generally T-shaped, defining an elongate body and a generally  
14   transverse head angled upward relative to the body, and includes a first side which is  
15   intended to contact the bone, and a second side opposite the first side. The body includes  
16   a plurality of countersunk screw holes for the extension of the bone screws therethrough,  
17   and optionally one or more substantially smaller alignment holes. The lower surfaces of  
18   the radial and ulnar side portions of the head are contoured upward (in a Z direction)  
19   relative to the remainder of the head to accommodate the lunate and scaphoid processes.  
20   An extension is provided at the head portion along the distal ulnar side of the head to  
21   buttress the volar lip (marginal fragment) of the lunate fossa of the radius bone, thereby  
22   providing support to maintain the wrist within the articular socket. Moreover, the  
23   contoured shape provides a stable shape that prevents rocking of the plate on the bone.

1 The upper and lower surfaces are chamfered to have a reduced profile that limits potential  
2 interface with the ligaments and soft tissue near the edge of the lunate fossa. The head  
3 includes a plurality of threaded peg holes for receiving the pegs therethrough. The peg  
4 holes are arranged into a first set provided in a proximal portion of the head, and a second  
5 relatively distal set preferably provided in the tapered portion of the head.

6  
7 The first set of the peg holes is substantially linearly arranged generally laterally  
8 across the head. The line of pegs is preferably slightly oblique relative to a longitudinal  
9 axis through the body of the plate. Axes through the first set of holes are preferably  
10 oblique relative to each other, and are preferably angled relative to each other in two  
11 dimensions such that pegs inserted therethrough are similarly obliquely angled relative to  
12 each other. The pegs in the first set of peg holes provide support for the dorsal aspect of  
13 the subchondral bone fragments.

14  
15 The second set of peg holes is provided relatively distal of the first set. The holes  
16 of the second set, if more than one are provided, are slightly out of alignment but  
17 generally linearly arranged. The pegs in the second set of peg holes provide support for  
18 the volar aspect of the subchondral bone, behind and substantially parallel to the articular  
19 bone surface.

20  
21 A distal alignment hole is provided generally between two peg holes of the second  
22 set of peg holes. At the upper surface of the plate, the distal alignment hole is  
23 substantially cylindrical, while at the lower surface, the hole is laterally oblong. One or

1 more proximal alignment holes of a size substantially smaller than the peg holes are  
2 provided substantially along a distal edge defined by a tangent line to shafts of pegs  
3 inserted in the first set of peg holes, and facilitate temporary fixation of the plate to the  
4 bone with K-wires. Furthermore, along the body two longitudinally displaced alignment  
5 holes are also provided. All of the alignment holes are sized to closely receive individual  
6 K-wires.

7  
8 The plate may be used in at least two different manners. According to a first use,  
9 the surgeon reduces a fracture and aligns the plate thereover. The surgeon then drills K-  
10 wires through the proximal alignment holes to temporarily fix the orientation of the head  
11 of the plate to the distal fragment. Once the alignment is so fixed, the fracture is  
12 examined, e.g., under fluoroscopy, to determine whether the K-wires are properly aligned  
13 relative to the articular surface. As the axes of the proximal alignment holes correspond  
14 to axes of adjacent peg holes, the fluoroscopically viewed K-wires provide an indication  
15 as to whether the pegs will be properly oriented. If the placement is correct, the K-wires  
16 maintain the position of the plate over the fracture. The peg holes may then be drilled  
17 with confidence that their locations and orientations are proper. If placement is not  
18 optimal, the K-wires can be removed and the surgeon has an opportunity to relocate  
19 and/or reorient the K-wires and drill again. Since each K-wire is of relatively small  
20 diameter, the bone is not significantly damaged by the drilling process and the surgeon is  
21 not committed to the initial drill location and/or orientation.

22

1           According to a second use, the plate may be used to correct a metaphyseal  
2   deformity (such as malformed fracture or congenital deformity). For such purposes, a K-  
3   wire is drilled into the bone parallel to the articular surface in the lateral view under  
4   fluoroscopy until one end of the K-wire is located within or through the bone and the  
5   other end is free. The free end of the K-wire is guided through the distal oblong  
6   alignment hole of the head of the plate, and the plate is slid down over the K-wire into  
7   position against the bone. The oblong alignment hole permits the plate to tilt laterally  
8   over the K-wire to sit flat on the bone, but does not permit movement of the plate over  
9   the K-wire in the anterior-posterior plane. The surgeon drills holes in the bone in  
10   alignment with the peg holes and then fixes the plate relative the bone with pegs. The  
11   bone is then cut, and the body of the plate is levered toward the shaft of the bone to re-  
12   orient the bone. The body of the plate is then fixed to the shaft to correct the anatomical  
13   defect.

14  
15           Additional objects and advantages of the invention will become apparent to those  
16   skilled in the art upon reference to the detailed description taken in conjunction with the  
17   provided figures.

18

## 19                           BRIEF DESCRIPTION OF THE DRAWINGS

20

21           Fig. 1 is a radial side elevation of a right-hand volar plate according to the  
22   invention, shown with pegs coupled thereto;

23

1            Fig. 2 is an ulnar side elevation of a right-hand volar plate according to the  
2 invention, shown with pegs coupled thereto;

3

4            Fig. 3 is top view of a right-hand volar plate according to the invention, shown  
5 with pegs and screws;

6

7            Fig. 4 is bottom view of a right-hand volar plate according to the invention,  
8 shown with pegs coupled thereto;

9

10           Fig. 5 is a perspective view of a right-hand volar plate according to the invention,  
11 shown with pegs coupled thereto and K-wires extending through body and proximal head  
12 alignment holes;

13

14           Fig. 6 is a front end view of a right-hand volar plate according to the invention,  
15 shown with pegs coupled thereto and K-wires extending through alignment holes; and

16

17           Figs. 7 through 12 illustrate a method of performing an osteotomy of the distal  
18 radius according to the invention.

19

## 20           DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

21

22           Turning now to Figs. 1 through 6, a fracture fixation system 100 according to the  
23 invention is shown. The system 100 is particularly adapted for aligning and stabilizing



1 multiple bone fragments in a dorsally displaced distal radius fracture (or Colles' fracture).  
2 The system 100 generally includes a substantially rigid T-shaped plate 102, commonly  
3 called a volar plate, bone screws 104 (Fig. 3), pegs 106, 108, and K-wires 110 (Figs. 5  
4 and 6). Pegs 106 have a threaded head and a non-threaded shaft, and pegs 108 have both  
5 a threaded head and a threaded shaft. Either pegs 106 or 108, or a combination thereof  
6 may be used at the discretion of the surgeon. Exemplar pegs are described in more detail  
7 in U.S. Pat. No. 6,364,882, which is hereby incorporated by reference herein in its  
8 entirety.

9  
10 The volar plate 102 shown in the figures is a right-hand plate intended to be  
11 positioned against the volar side of a fractured radius bone of the right arm. It is  
12 appreciated that a left-hand volar plate is substantially a mirror image of the plate shown  
13 and now described. The T-shaped plate 102 defines an elongate body 116, and a head  
14 118 angled upward (in the Z-direction) relative to the head. The angle  $\alpha$  between the  
15 head 118 and the body 116 is preferably approximately  $25^\circ$ . The head 118 includes a  
16 distal buttress 120 (i.e., the portion of the head distal a first set of peg holes 134,  
17 discussed below). The plate 102 has a thickness of preferably approximately 0.1 inch,  
18 and is preferably made from a titanium alloy, such as Ti-6Al-4V.

19  
20 Referring to Fig. 4, the body 116 includes four preferably countersunk screw  
21 holes 124, 125, 126, 127 for the extension of bone screws 104 therethrough (Fig. 2). One  
22 of the screw holes, 127, is preferably generally oval in shape permitting longitudinal

1 movement of the plate 102 relative to the shaft of a bone screw when the screw is not  
2 tightly clamped against the plate.

3

4 Referring to Figs. 3 and 4, according to one preferred aspect of the plate 102, the  
5 head portion 118 includes a first set of threaded peg holes 134 (for placement of pegs 106  
6 and/or 108 therein) and a second set of threaded peg holes 138 (for placement of pegs  
7 106 and/or 108 therein). The peg holes 134 of the first set are arranged substantially  
8 parallel to a line  $L_1$  that is preferably slightly skewed (e.g., by  $5^\circ$ - $10^\circ$ ) relative to a  
9 perpendicular  $P$  to the axis  $A$  of the body portion 116. Axes through the first set of peg  
10 holes (indicated by the pegs 106 extending therethrough) are preferably oblique relative  
11 to each other, and are preferably angled relative to each other in two dimensions,  
12 generally as described in commonly-owned U.S. Pat. No. 6,364,882, which is hereby  
13 incorporated by reference herein in its entirety. This orientation of the pegs operates to  
14 stabilize and secure the head 118 of the plate 102 on the bone even where such pegs 106  
15 do not have threaded shafts.

16

17 The second set of peg holes 138 is provided relatively distal of the first set of peg  
18 holes 134 and is most preferably primarily located in the buttress 120. Each of the peg  
19 holes 138 preferably defines an axis that is oblique relative to the other of peg holes 136  
20 and 138. Thus, each and every peg 106, 108 when positioned within respective peg holes  
21 134, 138 defines a distinct axis relative to the other pegs. Moreover, the axes of the peg  
22 holes 138 are preferably oriented relative to the axes of peg holes 134 such that pegs 106,

1 108 within peg holes 138 extend (or define axes which extend) between pegs (or axes  
2 thereof) within peg holes 134 in an interleaved manner.

3

4 Referring specifically to Figs. 1, 2, 5 and 6, according to another preferred aspect  
5 of the plate 102, in order to approximate the anatomy for ideal fracture support and  
6 maintain a low profile, the upper and lower surfaces 140, 142, respectively of the buttress  
7 120 are chamfered, with the chamfer of the lower surface 142 being contoured for the  
8 anatomical structure that it will overlie. In particular, the lower surface 142 at a radial-  
9 side portion 144 of the head portion 118 is contoured upward (in a Z direction) both  
10 distally and laterally to accommodate the bulky volar rim of the lunate fossa, and the  
11 lower surface 142 at an ulnar side portion 146 of the head 118 is contoured upward  
12 laterally relative to the remainder of the head to accommodate the relatively flat volar rim  
13 of the scaphoid fossa, as indicated by the visibility of these lower surfaces in the side  
14 views of Figs. 1 and 2 and head-on view of Fig. 6. The contoured shape (with generally  
15 three defined planes) provides a stable shape that prevents rocking of the plate on the  
16 bone. In addition, the upper and lower surfaces 140, 142 are chamfered to have a  
17 reduced profile that limits potential interface with the ligaments near the edge of the  
18 articular surface. A distal extension 148 is also provided at the ulnar side portion 146 to  
19 further buttress the volar lip (volar marginal fragment of the lunate fossa) of the articular  
20 socket of the radius bone, thereby providing support to maintain the wrist within the  
21 articular socket.

22

1 Referring specifically to Figs. 3 and 4, according to a further preferred aspect of  
2 the invention, the plate 102 is provided with body alignment holes 150, proximal head  
3 alignment holes 152a, 152b, 152c (generally 152), and a distal head alignment hole 154,  
4 each sized to closely accept standard Kirschner wires (K-wires), e.g., 0.7 – 1.2 mm in  
5 diameter. All the alignment holes 150, 152, 154 are substantially smaller in diameter  
6 (e.g., by thirty to fifty percent) than the shafts of screws 104 (approximately 3.15 mm in  
7 diameter) and the shafts of pegs 106, 108 (approximately 2.25 mm in diameter). The  
8 body alignment holes 150 are longitudinally displaced along the body portion 116 and  
9 provided at an oblique angle (preferably approximately 70°, as shown in Fig. 5) relative  
10 to the lower surface 158 of the body portion 116. The proximal head alignment holes  
11 152 alternate with the peg holes 134. A tangent line H to the distalmost points of the  
12 head alignment holes 152 is preferably substantially coincident or closely parallel with a  
13 line tangent to points on the circumferences of the shafts of pegs 106 inserted through  
14 holes 134 adjacent the head portion 118 of the plate 102. With respect to the proximal  
15 head alignment holes, it is appreciated that a shaft 106a of a peg is generally smaller in  
16 diameter than a head 106b of a peg (Fig. 6). Thus, a line tangent to the peg holes 134  
17 (each sized for receiving the head 106b of peg 106) will be closely located, but parallel,  
18 to a line tangent to a distalmost point on the respective alignment hole 152. Nevertheless,  
19 for purposes of the claims, both (i) a tangent line which is preferably substantially  
20 coincident with a line tangent to points on the circumferences of the shafts of pegs and  
21 (ii) a tangent line to a set of peg holes shall be considered to be “substantially coincident”  
22 with a line tangent to a distalmost point of an alignment hole 152. Axes through  
23 alignment holes 152 preferably generally approximate (within, e.g., 3°) the angle of an

1 axis of an adjacent peg hole 134. Distal head alignment hole 154 is provided between the  
2 central and radial-side peg holes 138, and has a circular upper opening, and a laterally  
3 oblong lower opening, as shown best in Fig. 6.

4  
5 The plate may be used in at least two different applications: fracture fixation and  
6 correction of a metaphyseal deformity. In either application, an incision is first made  
7 over the distal radius, and the pronator quadratus is reflected from its radial insertion  
8 exposing the entire distal radius ulnarly to the distal radioulnar joint. For fracture  
9 fixation, the surgeon reduces the fracture and aligns the plate 102 thereover. The surgeon  
10 then drills preferably two K-wires 110 through respective body alignment holes 150, and  
11 one or more K-wires through selected proximal head alignment holes 152 at the location  
12 at which the surgeon believes the pegs 106, 108 should be placed based on anatomical  
13 landmarks and/or fluoroscopic guidance. The K-wires temporarily fix the orientation of  
14 the plate to the distal fragment. While the fixation is temporary, it is relatively secure in  
15 view of the fact that the body alignment holes 150, proximal head alignment holes 152,  
16 and K-wires 110 therethrough are angled in different orientations relative to the lower  
17 surface of the plate. Once the alignment is so fixed, the fracture is examined, e.g., under  
18 fluoroscopy, to determine whether the K-wires 110 are properly aligned relative to the  
19 articular surface. As the axes of the proximal head alignment holes 152 correspond to  
20 axes of the adjacent peg holes 134, the fluoroscopically viewed K-wires 110 provide an  
21 indication as to whether the pegs 106, 108 will be properly oriented. If the placement is  
22 correct, the K-wires 110 maintain the position of the plate 102 over the fracture while  
23 holes in the bone are drilled through the screw holes 124, 125, 126, 127 for the screws

1 104 and peg holes 134, 138 for pegs 106, 108, with confidence that the locations and  
2 orientation of the screws and pegs inserted therein are anatomically appropriate. The K-  
3 wires can then be removed.

4

5 If fluoroscopic examination indicates that placement of the K-wires 110 is not  
6 optimal, the K-wires can be removed and the surgeon has an opportunity to relocate  
7 and/or reorient the K-wires and drill again. Since each K-wire is of relatively small  
8 diameter, the bone is not significantly damaged by the drilling process and the surgeon is  
9 not committed to the initial drill location and/or orientation.

10

11 The pegs 106 within peg holes 138 define projections that provide support at the  
12 volar aspect behind the articular surface of the bone surface. The sets of pegs 106, 108  
13 through peg holes 134, 138 preferably laterally alternate to provide tangential cradling of  
14 the subchondral bone. A preferred degree of subchondral support is provided with four  
15 peg holes 134 (and associated pegs) through the proximal portion of the head 118 of the  
16 plate, and three peg holes 138 (and associated pegs) through the distal portion of the head  
17 118. The fracture fixation system thereby defines a framework which substantially  
18 tangentially supports the bone fragments in their proper orientation. In accord with an  
19 alternate less preferred embodiment, suitable support may also be provided where the  
20 pegs 106 and 108 are parallel to each other or in another relative orientation or with fewer  
21 peg holes and/or pegs.

22

1           According to a second use, the plate may be used to correct a metaphyseal  
2   deformity 200 (such as malformed fracture or congenital deformity), as shown in Fig. 7.  
3   For such purposes, a K-wire 110 is drilled into the bone parallel to the articular surface S  
4   in the lateral view under fluoroscopy (Fig. 8). The free end of the K-wire 110 is guided  
5   through the oblong distal head alignment hole 154, and the plate 102 is slid down over  
6   the K-wire into position against the bone (Fig. 9). The oblong alignment hole 154  
7   permits the plate 102 to tilt laterally over the K-wire 110 to sit flat on the bone, but does  
8   not permit tilting of plate relative to the K-wire in the anterior-posterior plane. Once the  
9   plate 102 is seated against the bone, the surgeon drills holes in the bone in alignment with  
10   the peg holes 134, 138 (Fig. 3) and then fixes the plate relative the bone with pegs 106,  
11   108 (Fig. 10). The K-wire 110 is removed. The bone is then saw cut at 202 proximal the  
12   location of the head 118 of the plate 102 (Fig. 11), and the body 116 of the plate is  
13   levered toward the proximal diaphyseal bone 204, creating an open wedge 206 at the  
14   deformity (Fig. 12). When the body 116 of the plate 102 is in contact and longitudinal  
15   alignment with the diaphysis of the bone, the bone distal of the cut has been repositioned  
16   into the anatomically correct orientation relative to the shaft of the bone. The body 116  
17   of the plate 102 is then secured to the bone with screws 104. Post-operatively, the open  
18   wedge in the bone heals resulting in an anatomically correct distal radius.

19

20           While fixed single-angle pegs have been disclosed for use with the plate (i.e., the  
21   pegs may be fixed in respective threaded peg holes 134, 136 only coaxial with an axis  
22   defined by the respective peg holes), it is appreciated that an articulating peg system,  
23   such as that disclosed in co-owned U.S. Pat. No. 6,440,135 or co-owned and co-pending

1 U.S. Serial No. 10/159,612, both of which are hereby incorporated by reference herein in  
2 their entireties, may also be used. In such articulating peg systems, the peg holes and  
3 pegs are structurally adapted such that individual pegs may be fixed at any angle within a  
4 range of angles. In addition, while less preferable, one or both sets of the pegs may be  
5 replaced by preferably blunt tines which are integrated into the plate such that the plate  
6 and tines are unitary in construct. Similarly, other elongate projections may be coupled  
7 to the plate to define the desired support.

8  
9       There have been described and illustrated herein embodiments of a fixation plate,  
10 and particularly plates for fixation of distal radius fractures, as well as a method of  
11 aligning and stabilizing a distal radius fracture and performing an osteotomy. While  
12 particular embodiments of the invention have been described, it is not intended that the  
13 invention be limited thereto, as it is intended that the invention be as broad in scope as the  
14 art will allow and that the specification be read likewise. Thus, while particular  
15 materials, dimensions, and relative angles for particular elements of the system have been  
16 disclosed, it will be appreciated that other materials, dimensions, and relative angles may  
17 be used as well. In addition, while a particular number of screw holes in the volar plate  
18 and bone screws have been described, it will be understood another number of screw  
19 holes and screws may be provided. Further, fewer screws than the number of screw holes  
20 may be used to secure to the plate to the bone. Also, fewer or more peg holes and bone  
21 pegs may be used, preferably such that at least two pegs angled in two dimensions  
22 relative to each other are provided. In addition, while a particular preferred angle  
23 between the head and body has been disclosed, other angles can also be used. It will



- 1 therefore be appreciated by those skilled in the art that yet other modifications could be
- 2 made to the provided invention without deviating from its spirit and scope.